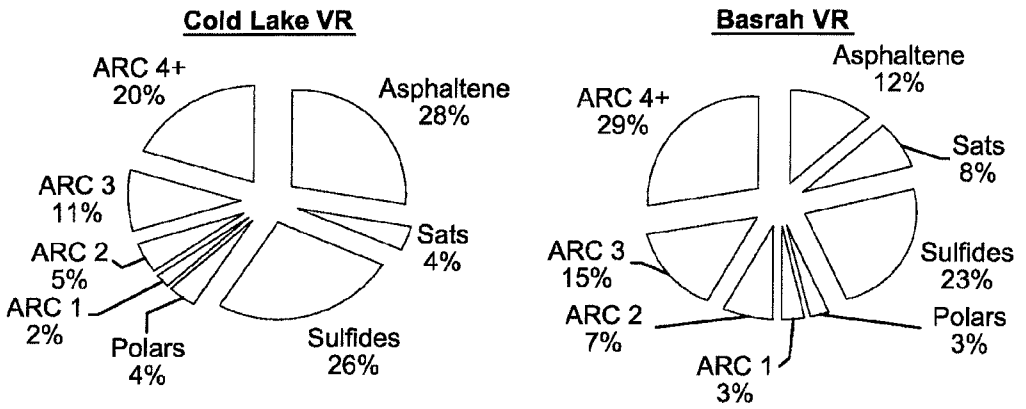

Cold Lake VR
ARC 4+
20%
Asphaltene
28%
ARC 3
11%
Sats
4%
ARC 2
5%
ARC 1
2%
Polars
4%
Sulfides
26%
Basrah VR
Asphaltene
12%
ARC 4+
29%
Sats
8%
ARC 3
15%
Sulfides
23%
ARC 2
7%
Polars
3%
ARC 1
3%

FIG. 1

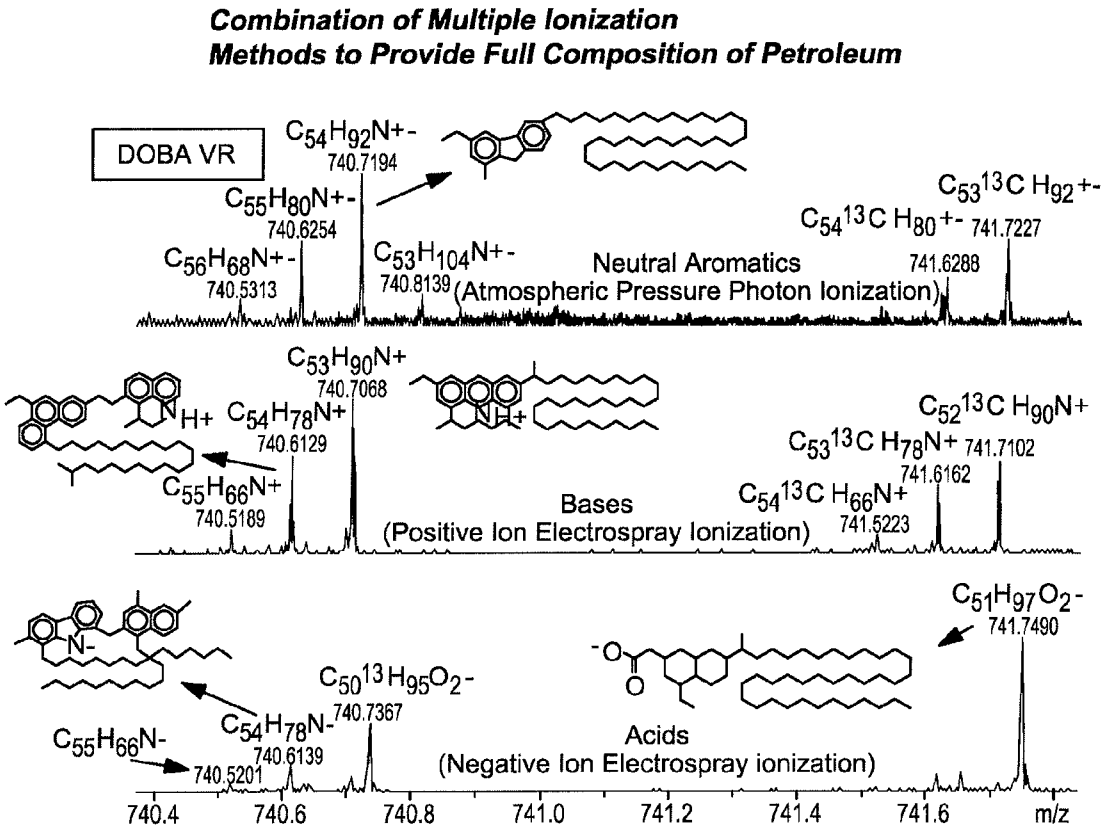

Combination of Multiple Ionization
Methods to Provide Full Composition of Petroleum
DOBA VR
C54H92N+-
740.7194
C55H80N+-
740.6254
C56H68N+-
740.5313
C53H104N+-
740.8139
Neutral Aromatics
(Atmospheric Pressure Photon Ionization)
C53 13C H92+-
C54 13C H80+- 741.7227
741.6288
C53H90N+
740.7068
C54H78N+
740.6129
C55H66N+
740.5189
Bases
(Positive Ion Electrospray Ionization)
C52 13C H90N+
C53 13C H78N+ 741.7102
741.6162
C54 13C H66N+
741.5223
C51H97O2-
741.7490
C50 13H95O2-
740.7367
C54H78N-
740.6139
C55H66N-
740.5201
Acids
(Negative Ion Electrospray ionization)
740.4
740.6
740.8
741.0
741.2
741.4
741.6
m/z

FIG. 2

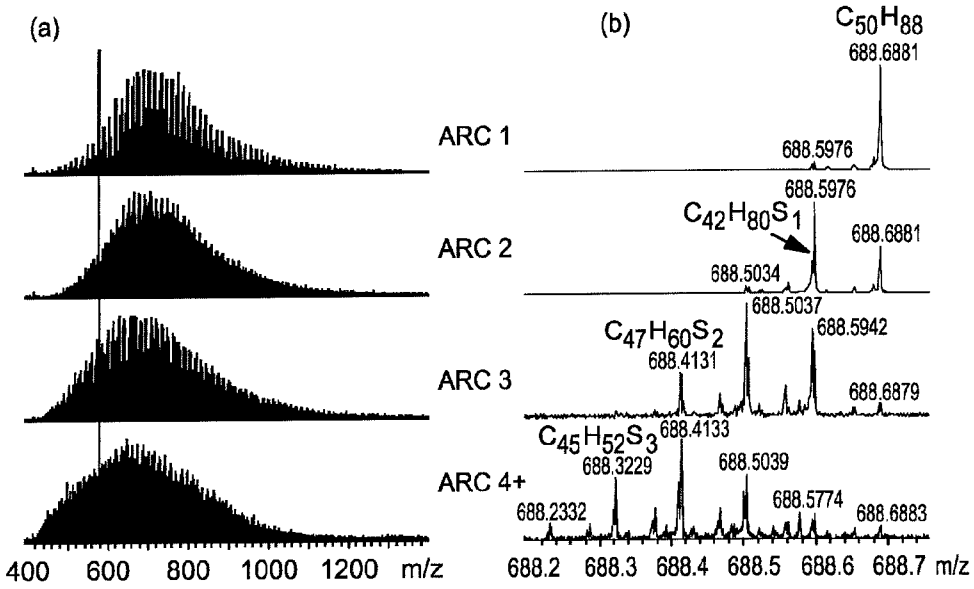

(a)
(b)
ARC 1
ARC 2
ARC 3
ARC 4+
400 600 800 1000 1200 m/z
688.2 688.3 688.4 688.5 688.6 688.7 m/z
C50H88
688.6881
688.5976
C42H80S1
688.5034
C47H60S2
688.4131
688.5037
688.5942
688.6879
C45H52S3
688.4133
688.3229
688.5039
688.5774
688.2332
688.6883

FIG. 3

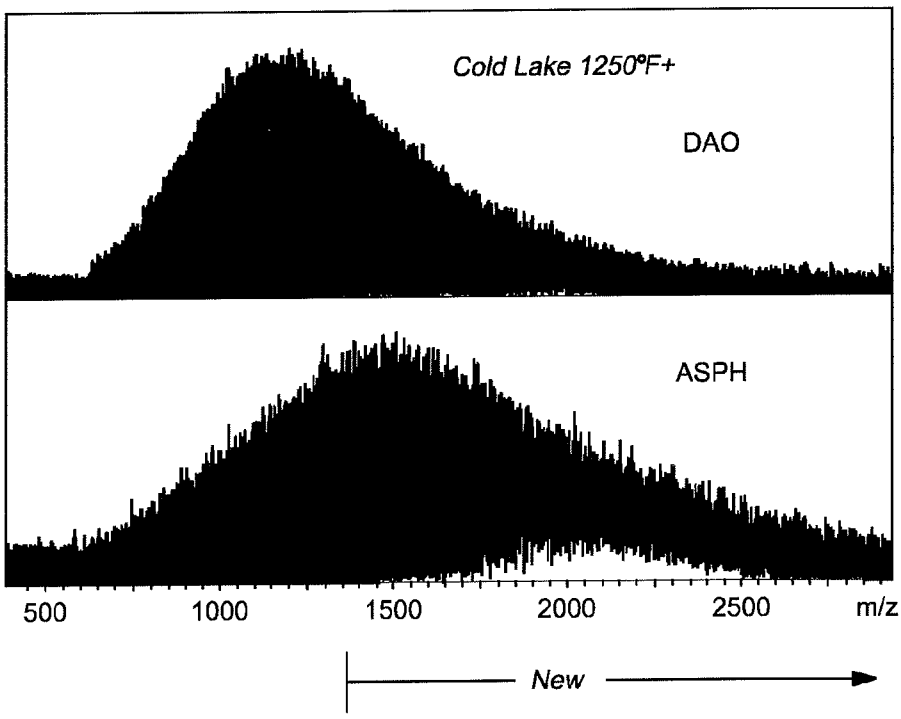

Cold Lake 1250°F+
DAO
ASPH
500 1000 1500 2000 2500 m/z
New

FIG. 4

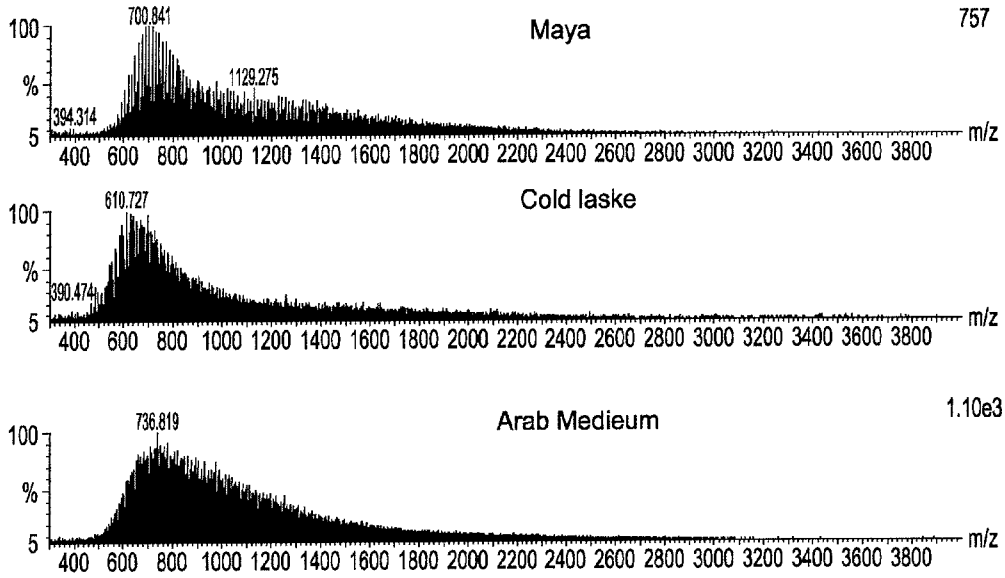
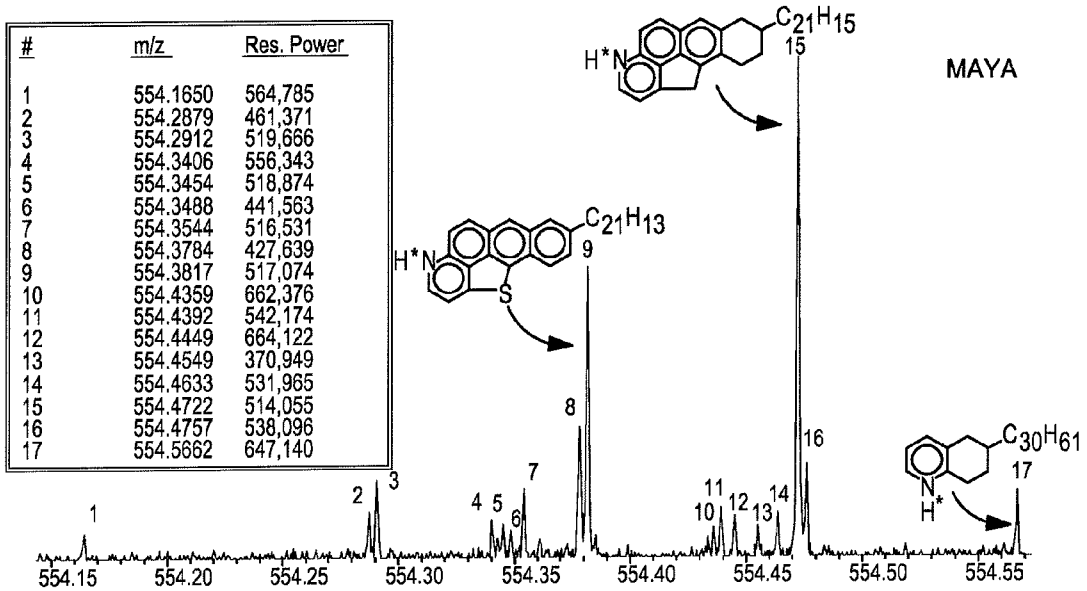


FIG. 5

Ultra-High Resolving Power (> 500,000)
Demonstrated in Wide Mass Range (200-1200 Da)

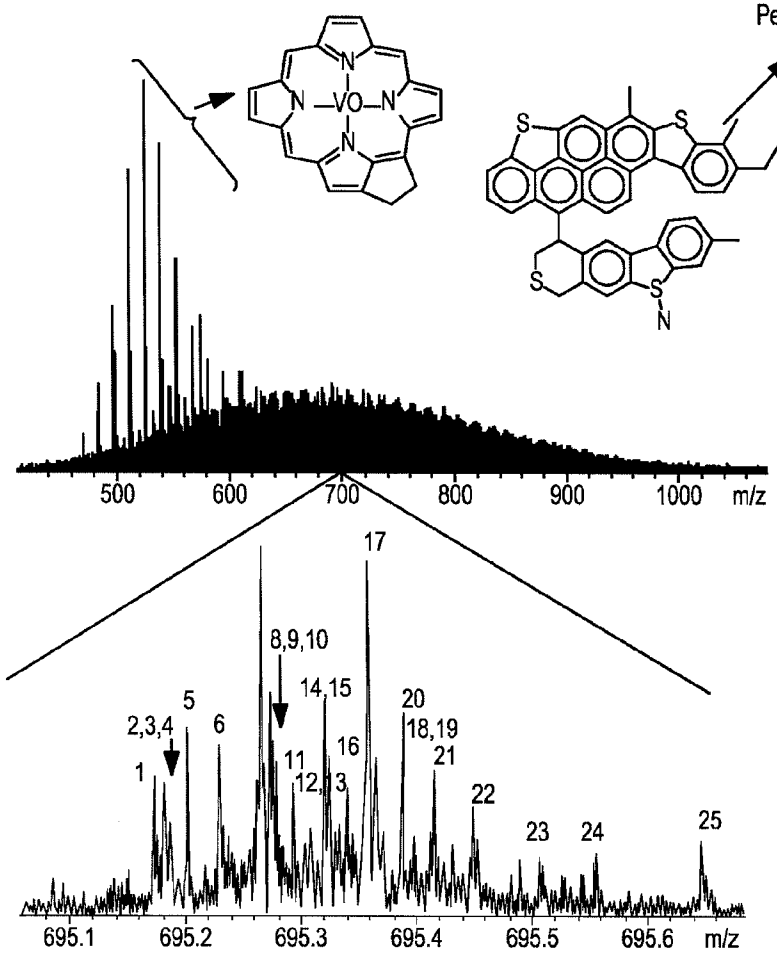
#	m/z	Res. Power
1	554.1650	564,785
2	554.2879	461,371
3	554.2912	519,666
4	554.3406	556,343
5	554.3454	518,874
6	554.3488	441,563
7	554.3544	516,531
8	554.3784	427,639
9	554.3817	517,074
10	554.4359	662,376
11	554.4392	542,174
12	554.4449	664,122
13	554.4549	370,949
14	554.4633	531,965
15	554.4722	514,055
16	554.4757	538,096
17	554.5662	647,140



- Positive Ion Electrospray Ionization (ESI^+)
- 17 components detected within 0.4 Da mass range (S/N>4)
- Mass to Charge ratio (m/z) corrected for mass of an electron (0.00054 Da)

FIG. 6

A Snapshot of Maya Asphaltene Composition



Peak No.	Exp. Mass	Calc. Mass	Error (mDa)	Formulae
1	695.1775	695.1775	0	$C_{46}H_{33}NS_3$
2	695.1854	695.1856	-0.2	$C_{48}{}^{13}CH_{34}S_3$
3	695.1886	695.1885	0.1	$C_{52}H_{25}NO_2$
4	695.1902	695.1901	0.1	$C_{17}H_{37}S_3+H$
5	695.2049	695.2049	0	$C_{42}H_{36}N_4OSV$
6	695.2316	695.2317	0	$C_{47}H_{37}NOS_2$
7	695.268	695.268	0	$C_{48}H_{41}NS_2$
8	695.2711	695.2714	-0.3	$C_{45}H_{45}NS_3$
9	695.2758	695.2762	-0.3	$C_{48}{}^{13}CH_{42}S_2$
10	695.2809	695.2806	0.3	$C_{49}H_{42}S_2+H$
11	695.2953	695.2955	-0.1	$C_{44}H_{44}N_4OV$
12	695.3098	695.3099	0	$C_{50}{}^{13}C_2H_{39}NO$
13	695.3222	695.3222	0.1	$C_{49}H_{45}NOS$
14	695.3255	695.3256	0	$C_{48}H_{49}NOS_2$
15	695.3335	695.3334	0.1	$C_{48}H_{45}N_3S$
16	695.3413	695.3415	-0.2	$C_{48}{}^{13}CH_{48}N_2S$
17	695.3585	695.3586	0	$C_{50}H_{49}NS$
18	695.3618	695.3619	-0.1	$C_{47}H_{53}NS_2$
19	695.3665	695.3667	-0.1	$C_{50}{}^{13}CH_{50}S$
20	695.3893	695.3894	0	$C_{43}H_{56}N_4OV$
21	695.3988	695.399	-0.2	$C_{48}{}^{13}CH_{54}N_2OS$
22	695.4161	695.4161	0.1	$C_{48}H_{57}NOS$
23	695.4322	695.4321	0.2	$C_{50}{}^{13}CH_{54}N_2$
24	695.4491	695.4491	0	$C_{52}H_{57}N$
25	695.6451	695.645	0.1	$C_{50}{}^{13}CH_{82}$

FIG. 7

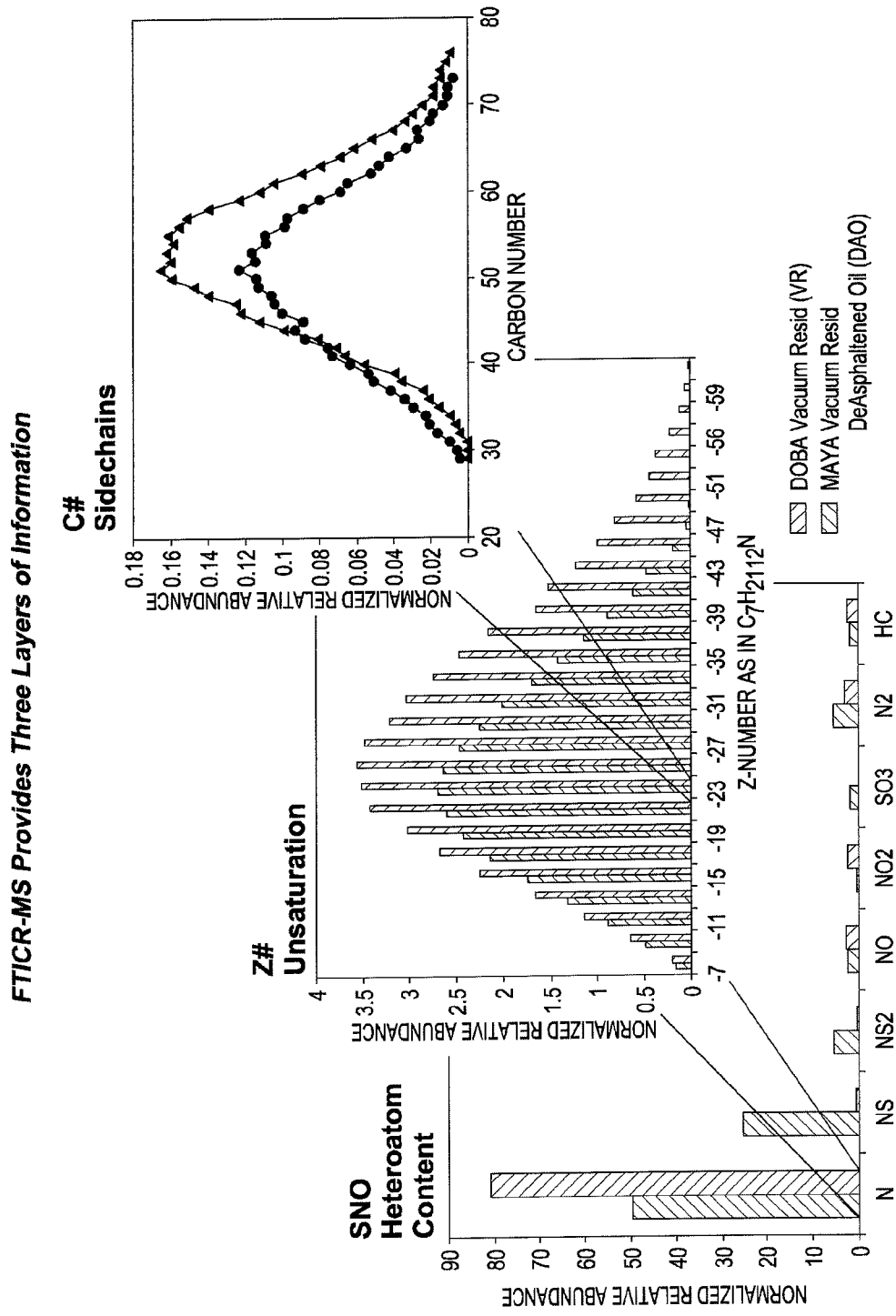

FTICR-MS Provides Three Layers of Information
C#
Sidechains
NORMALIZED RELATIVE ABUNDANCE
CARBON NUMBER
Z#
Unsaturation
NORMALIZED RELATIVE ABUNDANCE
Z-NUMBER AS IN C7H2112N
SNO
Heteroatom
Content
NORMALIZED RELATIVE ABUNDANCE
COMPOUND CLASSES
N
NS
NS2
NO
NO2
SO3
N2
HC
DOBA Vacuum Resid (VR)
MAYA Vacuum Resid
DeAsphaltened Oil (DAO)

FIG. 8

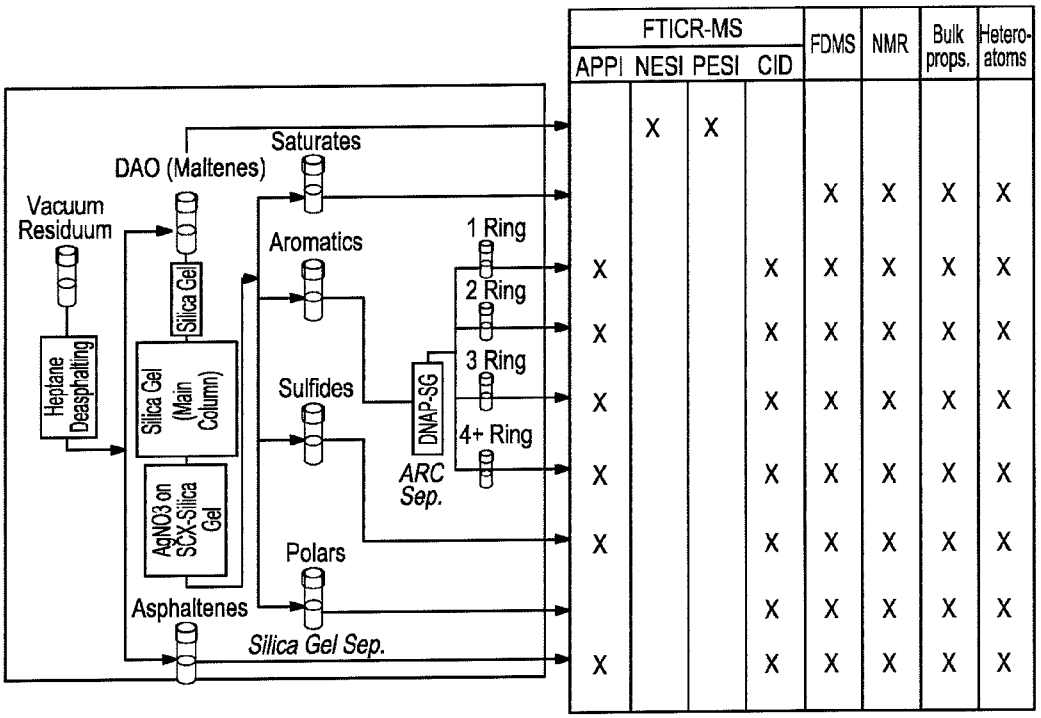

Vacuum Residuum
Heptane Deasphalting
DAO (Maltenes)
Silica Gel
Silica Gel (Main Column)
AgNO3 on SCX-Silica Gel
Asphaltenes
Saturates
Aromatics
Sulfides
Polars
DNAP-SG
ARC Sep.
1 Ring
2 Ring
3 Ring
4+ Ring
Silica Gel Sep.
FTICR-MS
APPI NESI PESI CID
FDMS
NMR
Bulk props.
Hetero-atoms

FIG. 9

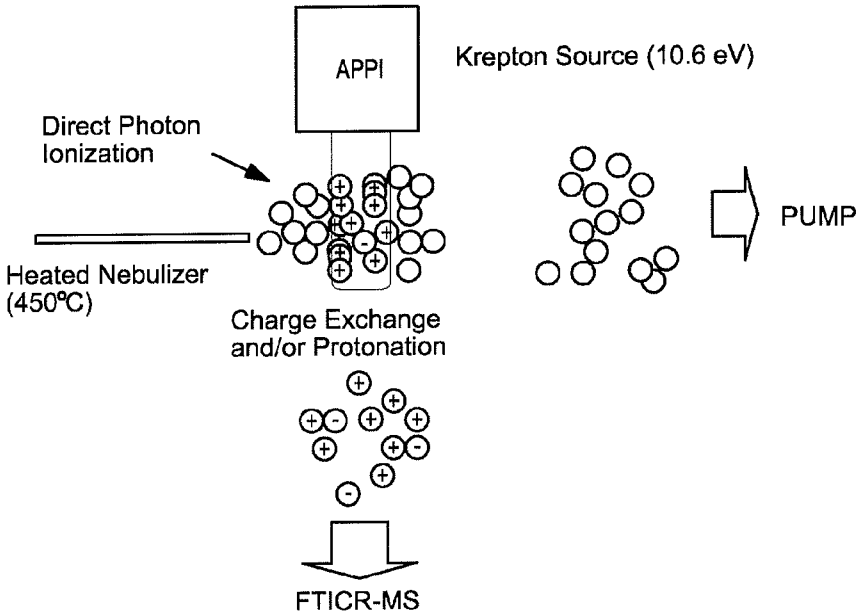

APPI
Krepton Source (10.6 eV)
Direct Photon Ionization
Heated Nebulizer (450°C)
Charge Exchange and/or Protonation
PUMP
FTICR-MS

FIG. 10

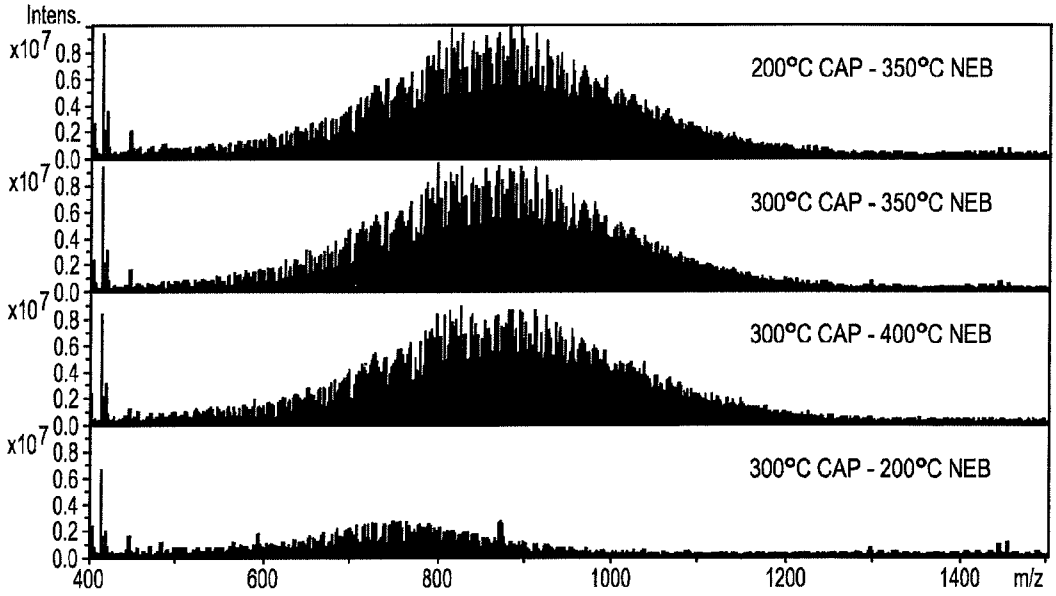

Intens.
x10^7
200°C CAP - 350°C NEB
300°C CAP - 350°C NEB
300°C CAP - 400°C NEB
300°C CAP - 200°C NEB
m/z

FIG. 11

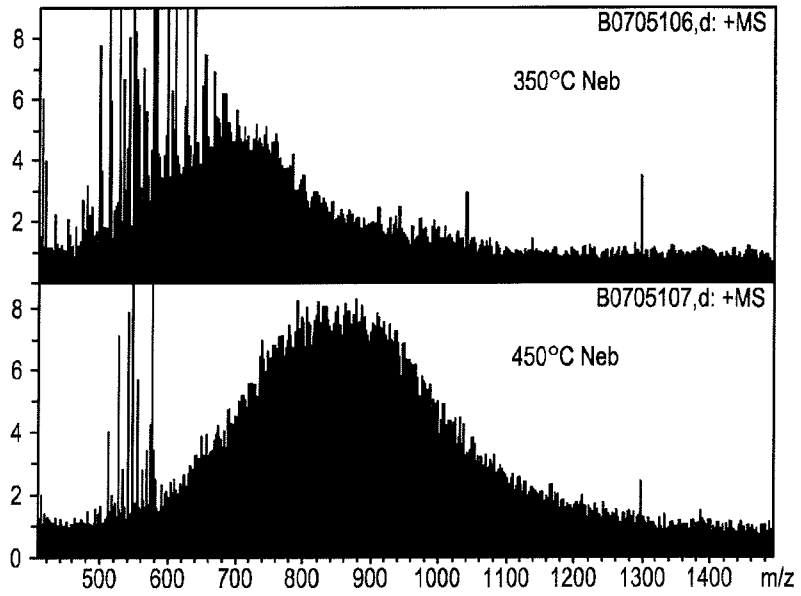

B0705106,d: +MS
350°C Neb
B0705107,d: +MS
450°C Neb
m/z

FIG. 12

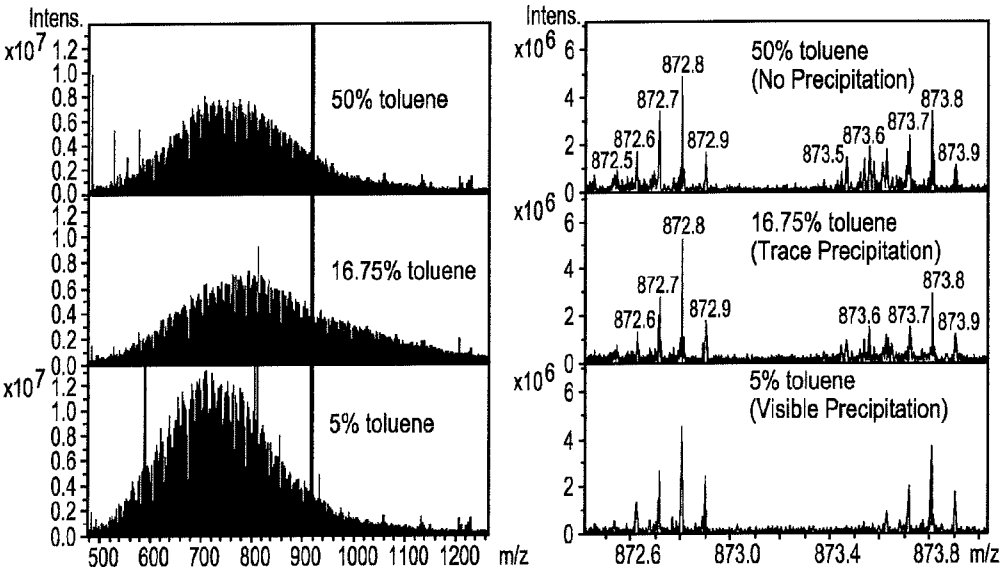

Intens.
x10^7
50% toluene
16.75% toluene
5% toluene
500 600 700 800 900 1000 1100 1200 m/z
Intens.
x10^6
50% toluene
(No Precipitation)
872.8
872.7
872.6
872.5
872.9
873.8
873.7
873.6
873.5
873.9
16.75% toluene
(Trace Precipitation)
5% toluene
(Visible Precipitation)
872.6 873.0 873.4 873.8 m/z

FIG. 13

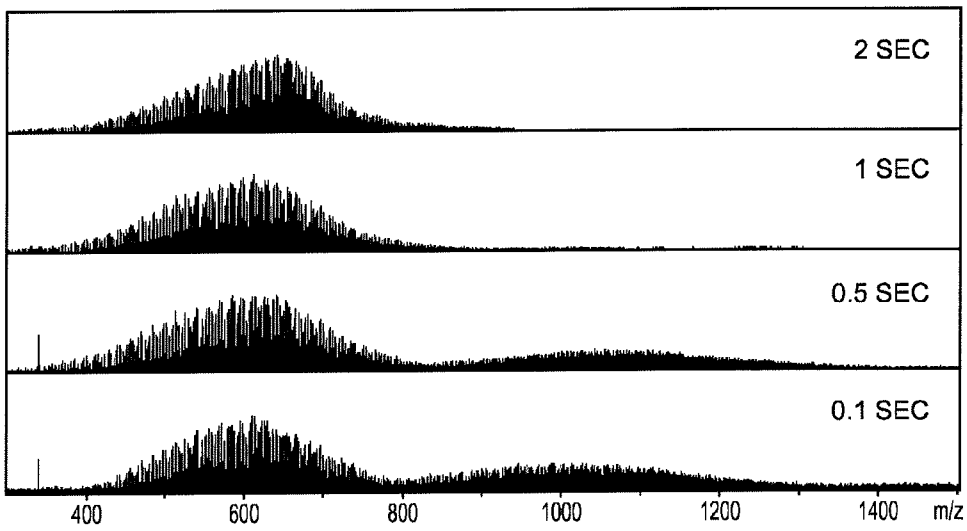

2 SEC
1 SEC
0.5 SEC
0.1 SEC
400 600 800 1000 1200 1400 m/z

FIG. 14

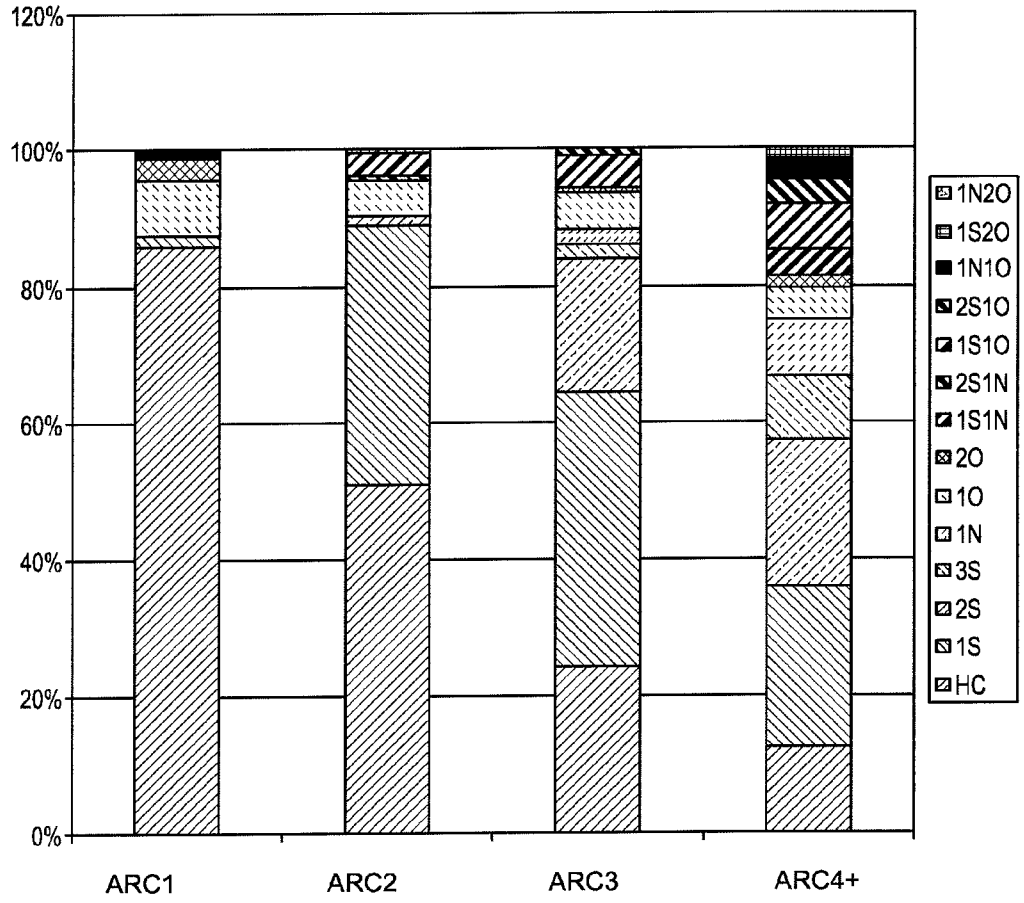

120%
100%
80%
60%
40%
20%
0%
ARC1
ARC2
ARC3
ARC4+
1N2O
1S2O
1N1O
2S1O
1S1O
2S1N
1S1N
2O
1O
1N
3S
2S
1S
HC

FIG. 15

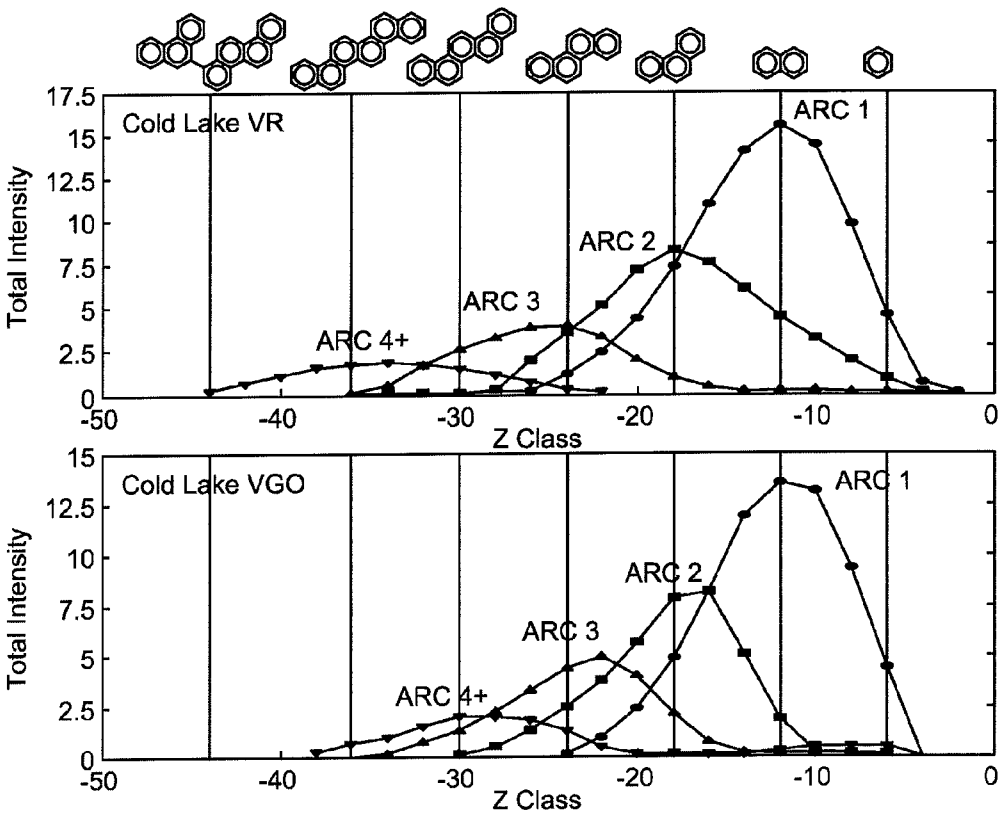

Cold Lake VR
ARC 1
ARC 2
ARC 3
ARC 4+
Total Intensity
Z Class
Cold Lake VGO
ARC 1
ARC 2
ARC 3
ARC 4+
Total Intensity
Z Class

FIG. 16

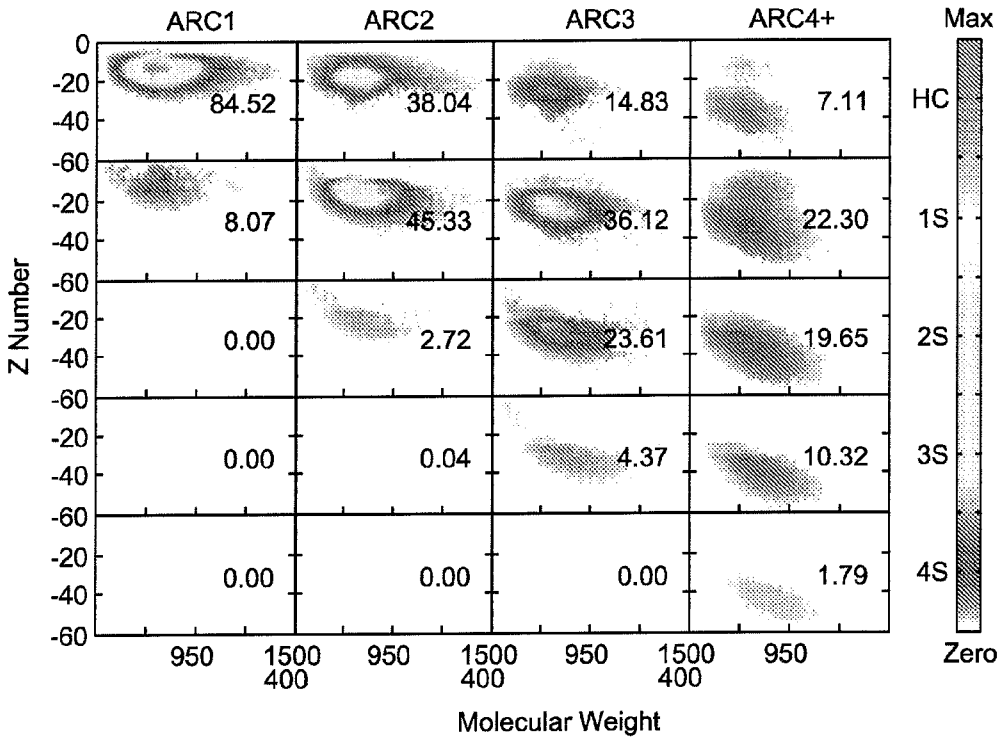

ARC1
ARC2
ARC3
ARC4+
Max
HC
1S
2S
3S
4S
Zero
84.52
38.04
14.83
7.11
8.07
45.33
36.12
22.30
0.00
2.72
23.61
19.65
0.00
0.04
4.37
10.32
0.00
0.00
0.00
1.79
Z Number
0
-20
-40
-60
950
1500
400
Molecular Weight

FIG. 17

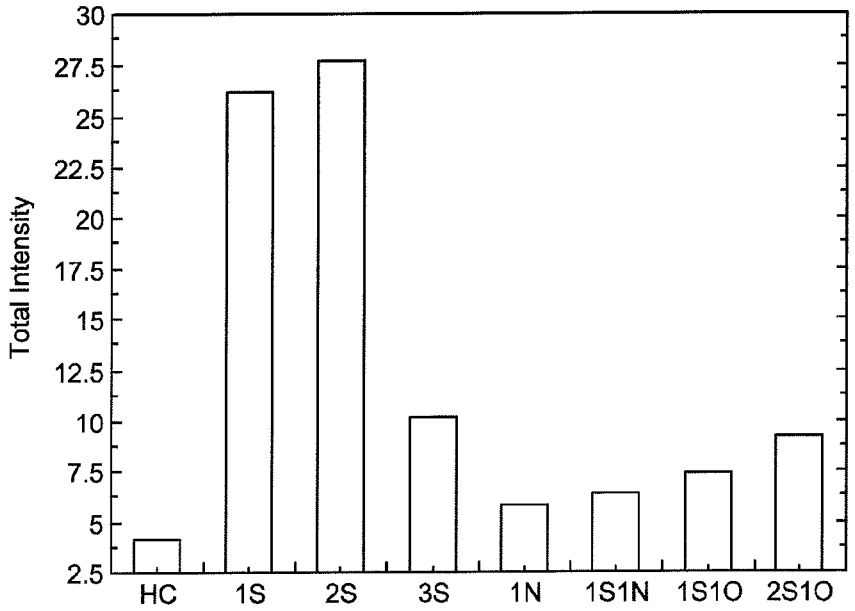

Total Intensity
30
27.5
25
22.5
20
17.5
15
12.5
10
7.5
5
2.5
HC
1S
2S
3S
1N
1S1N
1S1O
2S1O

FIG. 18

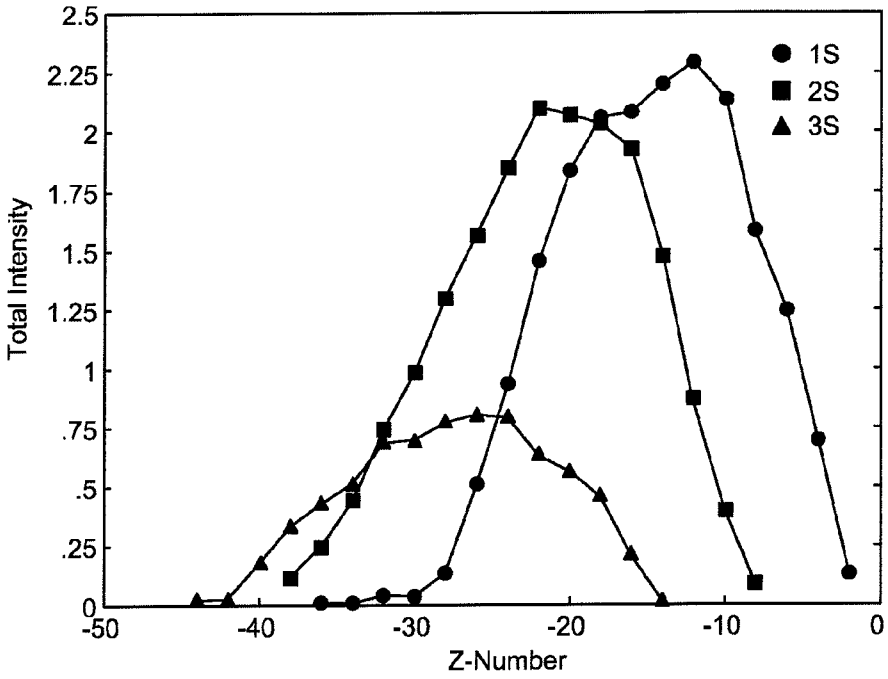

2.5
2.25
2
1.75
1.5
1.25
1
.75
.5
.25
0
Total Intensity
-50
-40
-30
-20
-10
0
Z-Number
1S
2S
3S

FIG. 19

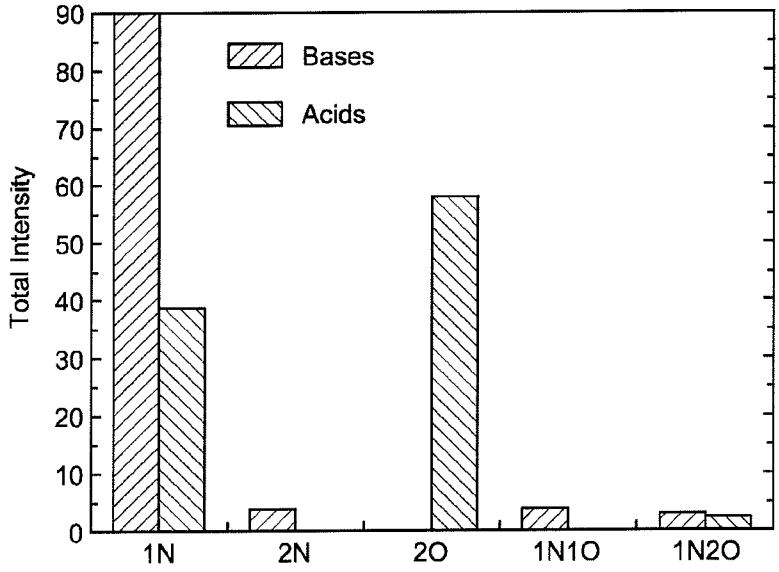

90
80
70
60
50
40
30
20
10
0
Total Intensity
Bases
Acids
1N
2N
2O
1N1O
1N2O

FIG. 20

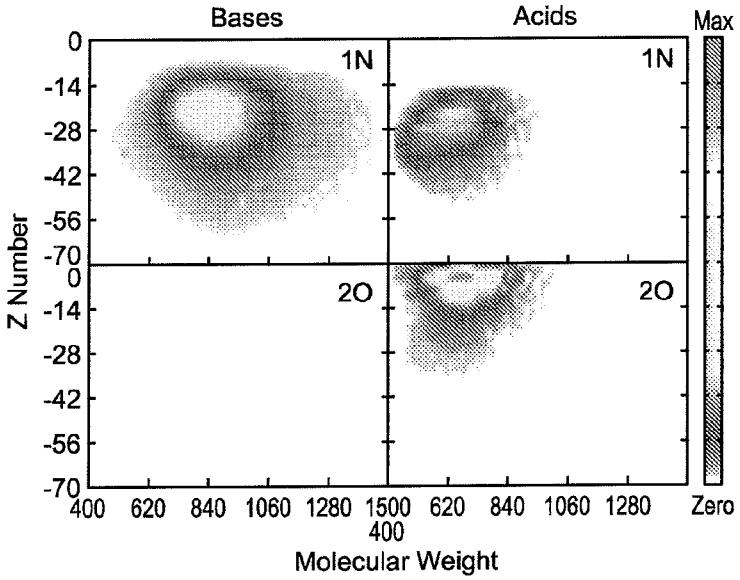

Bases
Acids
Max
1N
1N
2O
2O
0
-14
-28
-42
-56
-70
Z Number
400 620 840 1060 1280 1500
400 620 840 1060 1280
Zero
Molecular Weight

FIG. 21

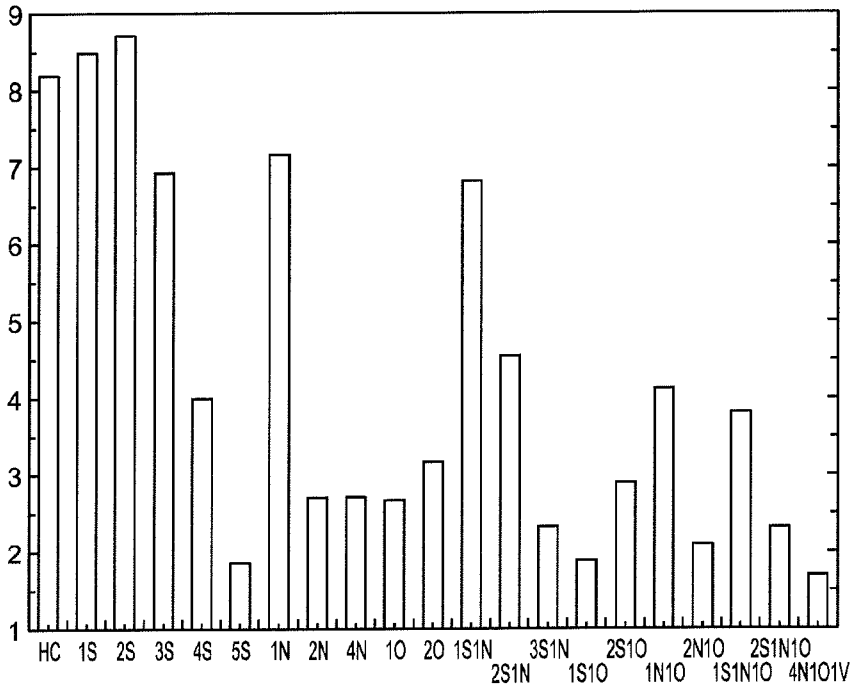

9
8
7
6
5
4
3
2
1
HC 1S 2S 3S 4S 5S 1N 2N 4N 1O 2O 1S1N 2S1N 3S1N 1S1O 2S1O 1N1O 2N1O 1S1N1O 2S1N1O 4N1O1V

FIG. 22

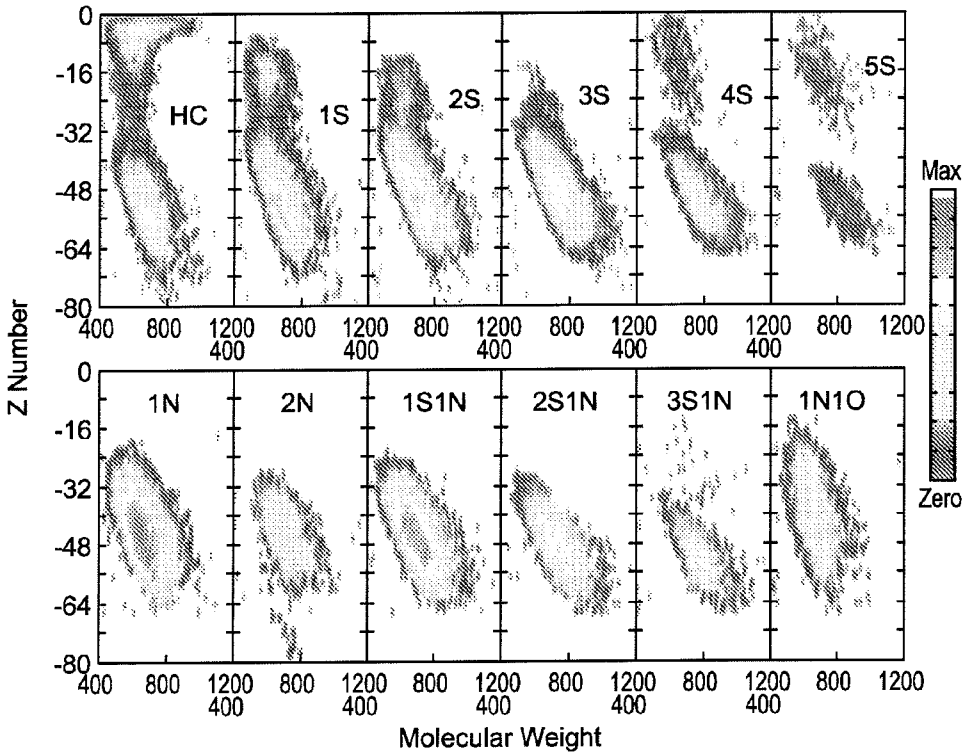


FIG. 23

On-line HPLC FTICR MS Configuration

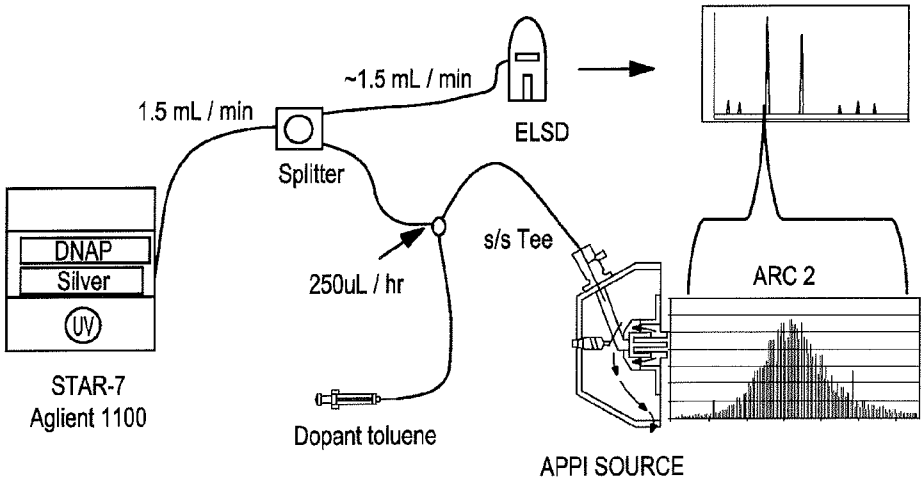


FIG. 24

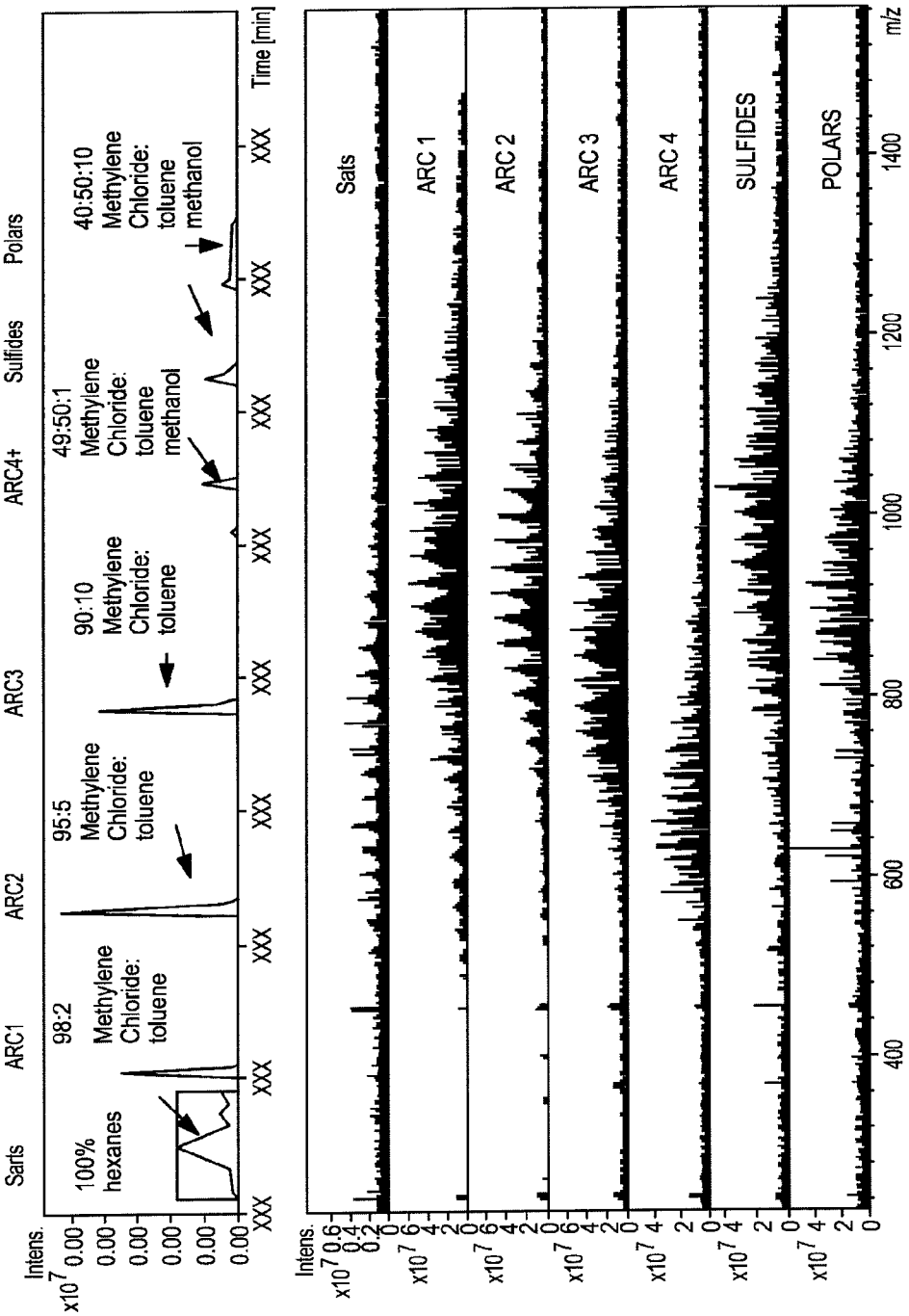
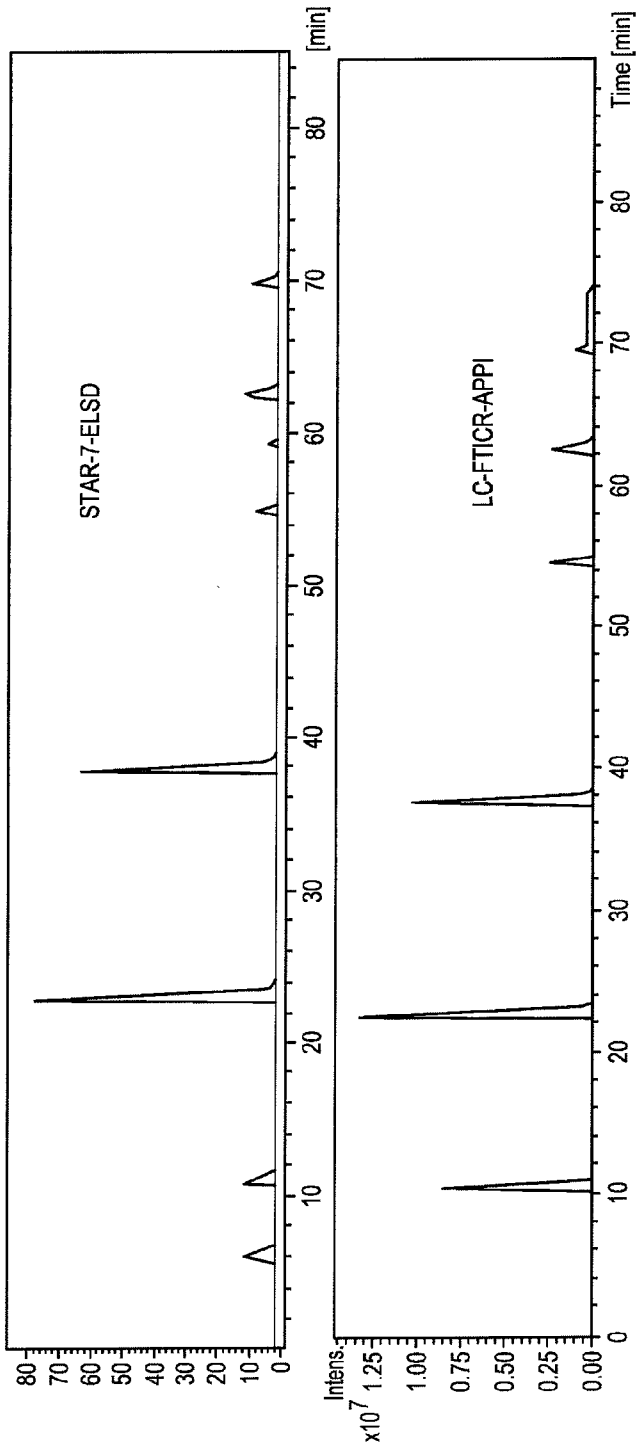

Intens.
x10 7
0.00
0.00
0.00
0.00
0.00
0.00
Saris
100%
hexanes
ARC1
98:2
Methylene
Chloride:
toluene
ARC2
95:5
Methylene
Chloride:
toluene
ARC3
90:10
Methylene
Chloride:
toluene
ARC4+
49:50:1
Methylene
Chloride:
toluene
methanol
Sulfides
40:50:10
Methylene
Chloride:
toluene
methanol
Polars
XXX
XXX
XXX
XXX
XXX
XXX
XXX
Time [min]
Intens.
Sats
ARC 1
ARC 2
ARC 3
ARC 4
SULFIDES
POLARS
400
600
800
1000
1200
1400
m/z

FIG. 25



	Sats	ARC-1	ARC-2	ARC-3	ARC-4	Sulfides	Polars
QC MEAN VALUES	*21.9*	*16.8*	*22.6*	*16.3*	*10.3*	*7.0*	*5.5*
STAR-7-ELSD	24.4	17.8	19.2	16.9	8.9	8.0	4.9
	22.4	18.1	21.7	18.6	6.1	7.4	5.6
LC-FTICR-APPI	N/A	15.7	28.3	21.5	3.1	6.4	2.5

FIG. 26